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APPLICATION NUMBER: *60/549,845*
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22651 U.S. PTO

030204

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

EXPRESS MAIL LABEL NO.: ***EV331292077US***

INVENTOR(s)/APPLICANT(s)

Given Name (first and middle [if any])	Family Name or Surname	RESIDENCE (City and either State or Foreign Country)
Paul R.	Kruesi	Golden, Colorado

22387 U.S. PTO 60/549845

030204

[ ] *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

"Carbon Fueled Fuel Cells for the Production of Electricity"

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

[X] Customer Number **22442** → Place Customer Number Bar Code Label here

Type Customer Number here

OR

[X] Firm or Individual Name	Sheridan Ross P.C.				
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Country	United States	Telephone	(303) 863-9700	Fax	(303) 863-0223

ENCLOSED APPLICATION PARTS (check all that apply)

X	Specification	Number of Pages	61		CD(s), Number	
	Drawing(s)	Number of Sheets		X	Other (specify)	Postcard receipt.
	Application Data Sheet. See 37 CFR 1.76					

METHOD OF PAYMENT FOR FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

X	Applicant claims small entity status. See 37 CFR 1.27		FILING FEE AMOUNT ($)
X	A check or money order is enclosed to cover the filing fees		$80.00
X	The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number:	19-1970	
	Payment by credit card. Form PTO-2038 is attached		

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ______________________.

Respectfully submitted,

SIGNATURE: Robert D. Traver

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Date: March 2, 2004

Registration No. 47,999

Docket No.: 5048-6-PROV

CARBON FUELED FUEL CELLS

Field of the Invention

The invention is in the field of the production of electricity or hydrogen by the reaction of carbon at an electrode producing carbonate ions

Background of the Invention

The need for lower cost electricity produced by means with fewer adverse environmental impacts has created a great deal of interest in fuel cells which create electricity by chemical reactions at electrodes. The outstanding advantage of the fuel cell is the very high efficiency by which it can convert the thermodynamic energy potential of the reactants into electricity. This efficiency can be as much as twice the efficiency of thermal conversion methods such as steam turbines and internal combustion engines. The fuel cell is inherently a mechanically simple device. It will lend itself to compact and comparatively inexpensive installations. Further, as the process does not involve extreme temperatures or large gas flows for the energy producing source, there are excellent opportunities to insure the recovery of undesirable impurities. A great deal of current development effort is being placed on hydrogen fuel cells with their advantageous oxidation production of water. The cells herein described can be used to produce hydrogen at very low cost, and of a quality perfectly suited to hydrogen fuel cell usage.

Hydrogen, despite the ease of its use and attractive water by-product, has certain disadvantages. It is very difficult to store. As it can be liquified at only extremely low temperatures, it practically is stored at very high pressures in cylinders of great strength, or stored as a compound such as metal hydrides, or even in nano-sized carbon tubes. In all of these alternates the light weight hydrogen is less than 15% of the weight of the hydrogen and storage device. The production of hydrogen of a purity suitable to sustained fuel cell use is another difficulty. Electrolytic production while meeting purity goals has heretofore presented no electric energy advantage Production by the reforming of natural gas (primarily methane) requires a large energy input for the reforming reaction, and starts from an increasingly expensive material. Carbon as illustrated by coal, is a more available and much lower cost fuel. The difficulties inherent in producing hydrogen by the water gas reaction which include the production of carbon monoxide, and a large endothermic reaction to which large amounts of heat must be supplied, makes it a complex and expensive process. Further, as carbon monoxide is well established as a poison to hydrogen cells, one is required to go through repeated water shift

reactions to achieve suitable hydrogen quality.

Carbon is widely available. Concentrated in coal it is the preferred and most heavily used source of energy for the production of electricity. Carbon-containing organic materials are ubiquitous in nature in the forms of wood, paper, plastics, cloth, and rubber, These materials constitute the major components of land-filled waste. In my co-pending patent applications (serial numbers 60/465,313 and 60/469,543) I show a means of converting all of the above materials to carbon and water. Carbon therefore will be available both inexpensively and with environmental advantage as a source for electricity production.

It has long been recognized that it would be very advantageous if carbon could be electrolytically processed to either hydrogen, or directly to electricity. In US Patent 4,226,683, Vesper Vaseen proposed an electrolytic cell that converted carbon to hydrogen by the carbon water reaction. The oxygen in the water producing carbon dioxide at one electrode while hydrogen was produced at the second electrode. The cell operated at a high temperature (180°C) and required a high pressure containment to overcome waters inherent gas state at this temperature. The cell further required a circulating organic depolarizer to remove the carbon dioxide and hydrogen from the system. In US Patent 6,200,697 Philip Pesavente describes a carbon-air fuel cell. The cell operates at 400°C in mixed fused metal hydroxides. Water is introduced as a gas in the incoming air (oxygen) stream. The reaction of water with certain chemicals assisting in the discharge of carbon dioxide from the carbonates formed in the reaction. The high temperature involved and the complexity of the carbon dioxide discharge are some of the disadvantages of this system.

Thus, there remains a need for a practical means for using carbon as the fuel source for electricity needs.

Description of the Invention

The reaction of water and carbon at moderate temperatures is particularly advantageous in that carbon materials readily adsorb water into the matrix. Where wetting is a difficulty, there are numerous very effective surfactants which enhance the water contact to the surface. The problem has been that at the normal boiling temperature of water, the kinetics of the carbon water reaction are not sufficient for a practical reaction. While being enclosed in a pressure vessel would overcome this, the vessel itself is a costly solution. There are, however, a number of materials that that hold water either as a compound or in a coordinated state. These include

sodium and potassium hydroxide; magnesium, calcium and strontium chloride; zinc chloride; monoammonium phosphate, and biammonium phosphate.

One or more of these materials serve as both the electrolyte, carrying a current at low resistance, and as the source of water-even at temperatures as high as 200°C. They carry this water at atmospheric pressure.

It is advantageous that the carbon have a high surface area. Reactivity of the carbon is enhanced by the intercalation of sodium and/or potassium ions. Certain catalysts such as cerium oxide are helpful in improving reactivity.

With sodium hydroxide or potassium hydroxide the carbon dioxide forms carbonates. Far from this being disadvantageous, as cited in US 6,200,697, it is advantageous as it provides a positive voltage. At a preferred temperature of 150°C this voltage is 0.17V (Na_2CO_3) or 0.21V (K_2CO_3). While marginal in a cell producing hydrogen, they can be practically used to produce hydrogen in a bipolar configuration. Alternately, these voltages at least make the inpressed voltage required for hydrogen production very small. Where the counter electrode uses oxygen (air) to produce water from the hydrogen ions an overall voltage of 1.32V (Na_2CO_3) 1.36V(K_2CO_3) can be calculated from the Gibbs Free Energy involved. This is substantially higher than would exist in a Hydrogen cell at the same temperature.

<u>Embodiment 1</u>

Assume 150°C		<u>Delta Gf</u>
$2KOH + C + H_2O \rightleftharpoons K_2CO_3 + 4H+ \ +4e$		+0.21V
$4e + 4H+ \rightleftharpoons 2H_2$		
or : $4e + 4H^+ + O_2 \rightleftharpoons 2H_2O$		+ 1.15
	Cell	+ 1.36 Volts
$2NaOH + C + H_2O \rightleftharpoons Na_2CO_3 + 4H^+ \ +4e$		+0.17V
$4e + 4H^+ \rightleftharpoons 2H_2$		
or $4e + 4H^+ + O_2 \rightleftharpoons 2H_2O$		+ 1.15
	Cell	+ 1.32V

Hydroxide regeneration: Assume 107°C

$K_2CO_3 + H_2O$ (KCL Media) $\rightleftharpoons 2K^+ + 2H^+ + CO_2 + 4e$ -1.20 V

Proton Membrane (Nafion TM Type)

$4e + 2K^+ + 2H^+ + O_2 \rightleftharpoons 2\,KOH$ +1.87

Cell +0.67 V

$Na_2CO_3 + H_2O$ (NaCl Media) $\rightleftharpoons 2Na^+ + 2H^+\ CO_2 + 4e$ -1.18 V

Proton Membrane (Nafion TM Type)

$4e + 2Na^+ + 2H^+ + O_2 \rightleftharpoons 2NaOH$ +1.90

Cell + 0.72

<u>Embodiment 2</u>

Using $SrCl_2\ 2H_2O$ or alternate water coordinating salt as media:

Note: $SrCl_2 + 2NaOH \rightleftharpoons Sr(OH)_2 + 2NaCl$

$Sr(OH)_2 + 2C + 4H_2O \rightleftharpoons Sr(HCO_3)_2 + 8H^+ + 8e$ +0.20V

$8e + 8H^+ \rightleftharpoons 4H_2$

or $8e + 8H^+ + 2O_2 \rightleftharpoons 4H_2O$ +1.15

Cell +1.35 Volts

And with an ion transmitting membrane such as Nafion

$Sr(HCO_3)_2 + C$ (SrCl and NaCl Media) $\rightleftharpoons 2Na^+ + 2H^+ + 3CO_2 + 4e$ -1.31 Volts

$4e + 2Na^+ + 2H^+ + O_2 \rightleftharpoons 2NaOH$ +1.84

Cell +0.56 Volts

One can further combine embodiment 1 and 2 in a continum using the $SrCl_2$ in H_20 media:

$2KOH + 3C + 4H_2O \rightleftharpoons 2K^+ + 10H^+ + 4CO_2 + 12e$ -0.362Volts

Proton Membrane (Nafion TM Type)

$12e + 2K^+ + 10H^+ + 3O_2 \rightleftharpoons 2KOH + 4H_2O$ +1.38

Cell +1.02 Volts

In this case, the potassium hydroxide and water generated at the cathode are recycled to the anode and the single cell regenerates itself with a continuous feed of carbon being released as carbon dioxide. One can summarize the cell as:

$3C + 3O_2 \rightleftharpoons 3CO_2$ Gibbs Free Energy Voltage $\rightleftharpoons$ + 1.02 V (150°C)

The numbers for the cells using sodium hydroxide are similar:

Cell (1) + (2)	+1.48 V
Cell (3)	+0.56 V
Combined	+1.02V

The combination of embodiments (1) and (2) can be used to produce hydrogen. In either the potassium or sodium case, this will result in three carbons producing four hydrogens at a net voltage of 0.75Volts. One could thereby produce both hydrogen and electricity.

In the cells where the hydrated chlorides are the media or electrolyte, there are interactions between the chloride media and the hydoxides used. Far from an inconvenience, given a measured addition of the carbon with the hydroxide interactions at moderate but useful concentrations allow for greater reagent solubility and consequently easier operation. It is therefore very advantageous to operate a single cell with hydrated electrolyte modified with a constantly-recycled hydroxide and water with steady, measured (by power demand) addition of carbon to provide a simple effective generator of electricity.

Embodiment 4

In a hydrated electrolyte, the following alternate cells utilizing a hydroxide or hydrated oxide which changes valence state at the anode and cathode and therefore generates carbonates at the anode and discharges carbon dioxide at the cathode are also feasible. For example:

$Fe(OH)_3 + C \rightleftharpoons FeCO_3 + 3H^+ + 3e$

$3e + 3H^+ + FeCO_3 + O_2 \rightleftharpoons Fe(OH)_3 + CO_2$

$MnO_2 + H_2O + C \rightleftharpoons MnCO_3 + 2H^+ + 2e$

$2e + 2H^+ + O_2 + MnCO_3 \rightleftharpoons MnO_2 + H_2O + CO_2$

$2Ce(OH)_4 + H_2O + 3C \rightleftharpoons Ce_2(CO_3)_3 + 10H^+ + 10e$

$10e + 10H^+ + 3O_2 + Ce_2(CO_3)_3 \rightleftharpoons 2Ce(OH)_4 + H_2O + 3CO_2$

It will be recognized that in each of these examples, the net reaction is $C + O_2 = CO_2$ and therefore, each of these cells will produce a theoretical voltage of 1.02 Volts at 150°C.

Embodiment 5

There are a great many important applications for chlorine which is an electrolysis product. By combining the operation of a carbon fuel cell with chlorine production, one can greatly decrease the cost of chlorine production. As an Example:

$2NaCl + 1/2\ C + H_20 \rightleftharpoons Cl_2 + 2Na^+ + 2H^+ + 1/2\ CO_2 + 4e$

Nafion Type Membrane

$2Na^+ + 2H^+ + 4e + O_2 \rightleftharpoons 2NaOH$ Net -0.04 V

$2NaCl + C + 2H_20 \rightleftharpoons Cl_2 + 2Na^+ + 4H^+ + CO_2 + 6e$

Nafion Type Membrane

$6e + 2Na^+ + 4H^+ + 11/2\ O_2 \rightleftharpoons 2NaOH + H_2O$ Net +0.31 Volts

This cell teamed in arrangement with carbon-fueled cells producing power not only produces chlorine, but electric power at the same time.

Embodiment 6

Using Hydrated alkaline earth chloride as media:

Example of ammines $Cu(NH_3)2Cl_2$; $Mg(NH_3)2Cl_2$ etc:

$Zn(NH_3)2Cl_2 + C + 3H_2O \rightleftharpoons (NH_4)2CO_3 + ZnCl_3 + 4H^+ + 4e$ + 0.07V

$4e + (NH_4)2CO_3 + ZnCl_2 + O_2 \rightleftharpoons Zn(NH_3)Cl_2 + CO_2 + 3H_2O$ + 0.95 V

Cell + 1.02 V

Embodiment 7

Metal fuel cell combined with Carbon

$$Zn + 3H_2O + C \rightleftharpoons ZnCO_3 + 6H+ 6e \qquad +0.02\ V$$

$$6e + 6H+ \ + 30_2 \rightleftharpoons 3H_20 \qquad +1.15$$

$$\text{Cell } + 1.17\ V$$

Methods of Performing the Invention.

The fuel cells to be used in this invention consist of an anode, cathode, and a membrane that separates the two electrodes. It is desirable that the anode be inert in the various electrolytes here proposed and that they be suited to the decomposition of carbon. Examples of suitable electrodes are the carbon-platinum composite anodes used in hydrogen cell anodes, and the DSA (TM) Titanium electrodes modified by iridium addition. The cathodes are the gas permeable carbon platinum cathodes typical of hydrogen fuel cells or the nickel gas permeable electrodes well established for alkaline cell use. In most of the embodiments cited membranes of the type used as alkaline battery plate separaters are used. Where it is desired to regenerate hydroxides the proton transfer membranes such as the well established nafion 112 or 117 (TM) may be used. A particularly advantages membrane of the proton transfer type is being developed at Case Western Reserve University and is described in by Ma et al. in *The Journal of the Electrochemical Society,* vol. 151(1) January 2004 page A8-A16. The polybenzidazole membrane cited is specifically chosen for temperatures as high as 200°C and is suited to electrolytes of strong alkalis, and phosphates.

The electrolytes cited are chosen on the basis of holding substantial contents of water at atmospheric pressure and at temperatures up to 180°C. When regenerating sodium or potassium hydroxide in a sodium chloride or potassium chloride solution, the temperature is limited by the boiling point of water at about 108°C in high salt concentration. Fortunately, the anodic carbon reaction in these media is enhance by the formation of hypochlorites which improve the kinetics of the reaction at this temperature. There are opposing forces in determining the best temperatures to conduct these reactions. The kinetics of the carbon reaction greatly improve with temperature. Thus the current production at 100°C, while noticeable, is small compared to

that at 150°C.

On the contrary, the conductivity of the hydrated chlorides, and to a lesser extent the hydroxides, decreases as the temperature rises and the molar amount of water associated with the salt declines. There is then, with each electrolyte, an optimal temperature for operation.

The preferred temperatures fall within the range of 100°C to 180°C. The preferred range with sodium hydroxide is 130°C to 175°C. Most preferred 135°C to 145°C. With Potassium hydroxide, the preferred range is 130°C to 160°C with the most preferred range being 140°C to 150°C. With the hydrated chlorides the preferred range is 130°C to 160°C and in the case of zinc chloride 120°C to 140°C. The ammonium phosphates are preferred to be in the temperature range of 120°C to 170°C, most preferred 130°C to 150C°C.

Preferably, the carbon to be used as fuel has the highest possible surface area. It is further desirable that the carbon be an electrical conductor. In my co-pending process for the production of carbon from a wide variety of organic materials including coal, means where found to enhance the conductivity of the carbon produced. These included the effect of the addition of sodium or potassium ions during the coarse of carbon preparation.

Carbon has a degree of hydrophilic characteristics which hinder its wetting by the electrolytes cited herein. I have overcome this by adding small amounts of surfactant to the electrolyte carbon mixture. A specific agent used has been Dial(TM) liquid hand cleaner. This is very effective at low doses.

It should be recognized that because the carbon being used for hydrogen or for electric power production comes from a wide variety of sources, there will be solid residue of depleted carbon in the anolyte electrolyte. Provision is made for the discharge of the residues, the recovery of co-discharged carbon and the recycle of discharged electrolyte.

In the conversion of various hydrocarbons to a carbon rich source for the purposes of this invention, it is very difficult to totally remove all the hydrogen contained in the hydrogen - carbon bonds of the originating material. This hydrogen provides no difficulty in this process provided it is sufficiently low enough to have lost the character of an elastomer or plastic and to have assumed the character of a not-perfectly-pure carbon. In the reaction of residual carbon - hydrogen bond material, the hydrogen ions will join those created by the hydroxyl carbon reaction and at the cathode be oxidized to hydrogen, hydroxyl or water.

Alkali Cell Trial 2/18/04

KOH 425gm + 500g H_2O = 45% KOH 700ml 1.32
100ml + 1g Ac - 100mls
@ 70° in 50°C Voltage open circuit 0.034V
30ohms.

Time	Temp Reservoir	Temp C	Temp Reg	Volts	Amps	
8 40	68	73	38	0.03V	—	Not circulating C Nsa)
8 50	75	68	52	0.04V	—	Circulating Air at cell
904	90	55	57	0.045V	—	"
920	100	62	60	0.045	0.24A	2 ohm
933	105	61	62	0.055	0.27A ÷10	
942	109	74	63	0.56	0.28A	increase circulation
1002	110	76	64	0.063	0.32A	
10.15	112	76	68	0.09	0.44A	
10:22	114	75	60	0.11	0.50A	
10:30	114	75	60	0.15	~~0.9A~~ 0.2A 0.1A	
10:40	115	75	60	0.15 open circuit	0.3A	0.1 A.r
10 50	116	75	60	0.2	0.8	
11 02	121	75	59	0.0 1 ohm	read 0.1 ch	
11 06	?			0.25		
11 20	133	75	57	0.5	0.1A failing	

Second Cell Run
Alkali Cell

2/15/04
[illegible]

Time	Temp Plasma	Temp S Probe	Temp 4.7 [illegible]	Volts 5 mil open circ	Amps 5 mil	
915	98	40	48			0.05 Air
925	110	65	51	.025	.018	Outside of cell = 35°C
940	120	63	52	.027	.020	
953	120	76	58	.043	.04	
1005	120	71	70	.05	.08	
1037	123	73	71	0.4	.15	Cell ≈ 50°C
1058	129	72	68	0.5	Monitor 0.2	0.1 Air
1115	131	70	67	0.57	0.25	

3rd Strontium Hydride Run Feb 23, 2004

Time	Reservoir Temp	C Rod Temp	Air Lift Temp	Air Flow	Voltage	Amps.
1030A	58	118	34	0.1		
1:38	90	60	64	0.1	0.1	.002
1040	100	70	70	0.1	0.04	.003

Heater Failure

	105PM	140		43	0.1	0.04	.003
	1:17	140	70	60	0.1	0.04	
	142	136		65			
Cell 46 61 47	147	105	95	100	0.1	0.1	.01
	150	115	85	94	0.1	0.25	0.15
57	205	108	90	100	0.2	0.25	0.2
Amp .024 / 1	209	115	90	95	0.05		
	215	122	93	100	0.2 (.02)	0.3	0.2
67	218	125	91	100	0.100 .010 .05	0.3	

1.0 Ohm Resistor Voltage drop .03v 0.01 Air Flow

~~235 120 100~~

236	120	83	100	.015	.36V	—
240	125	90	107			
245	130	93	110	0005	0.440	0.1A
250	135 Boils	97	115	0.01	0.5V	0.3A

872
- 57
815 H_2O Reagents 372% Load

1045

436	230	500	57
$SrCO_3$ + 2HCl →		$SrCl_2$ +	H_2O
147.63	72.916	158.5	18.016

Fuel Cell

1.907
.570
1.237

411 gms Steel 921 g 6x

Strontium Chloride Media

Feb 25, 2003

[signature]

pH 10.4 1 g Ac

Time	Temp 1 (Reservoir)	Temp 2 (Column)	Temp 3 (Airlift)	Air mL/min	Volts	Amps
1006	95	45	89	5	0	.0003 Amp
1015	104	72	85	5	.025	.0004
1025	105	77	76	5	.025	.0005
1030	106	79	64	5	.04	.0008
48-46 1045	114	63	50		.06	.0012

Feb 26, 2007
Frank Khan

SrCl2 make up 400 mls 37% Acid
472 gms
175 gms 2.368 m's SrCO3 350g
142.63
889 gms 45%
SrCl2 398.8

Time	Res Temp	C Temp	Repl Temp	Air Flow	Volts	Amps	
1028	85	71	77	0	.0	.0001	plug in Carbon Loop
1047	100	74	90	[illegible]	.02	.01A	
1056	90	82	78	10	0.3	.02	
83-57 1103	95	80	80	10	0.3	.04	
1110	108	73	82	5	0.3	.04	
1116	106	73	84	5	0.2	.04	
				10	0.3 .05	.04	
1120	115	73	86	15	.05	.05	
59 1125	115	74	85	20	.05	.06	
1130	120	74	85	20 10	.05V 0.35 open	.073	
1140	130	74	85	20	.05V	.08 Amp	
64 57 1143	135	74	87	40	.05V	.084	
1148	140	73	85	40	.05V open air 0.3V	.09	

$SrCl_2$ - SrOH pH 10.
OrZ; AC

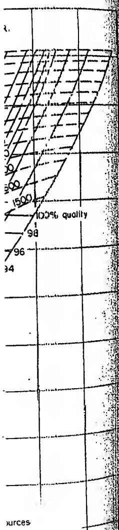
March 1, 2004

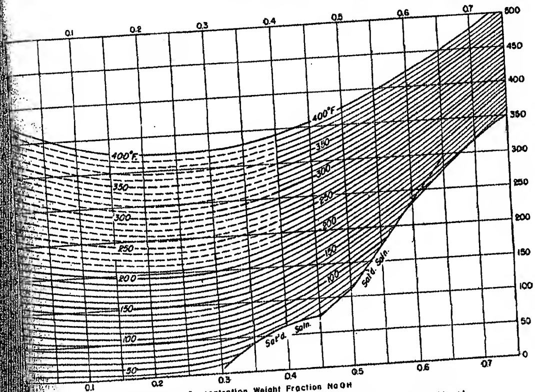
[signature]

Pump		Time	Temp Recir	Temp C	Temp Regula	Air	~~Current~~ Volts	Amps	Comment
1.5	0.4V on	10:07	80	80 off	74	off	-0.4V		40 ohms back emf
		1018	86	72	78	10	+.15V	.003A	
H		1025	87	73	79	10	~0.01	.16A	Open ckt 0.1V
110	64<84	1032	90	78	81	10	~~.025~~ 0.1	~~.05~~ .013A 0.178	0.2
		1040	95	82	85	10	~~.025~~ 0.14	.18A	

Heater Current out

Perry Chemical Engineers' Hand Book
6th Edition





Enthalpy-concentration diagram for aqueous sodium hydroxide at 1 atm. Reference states: enthalpy of liquid 32°F and vapor pressure is zero; partial molal enthalpy of infinitely dilute NaOH solution at 64°F and 1 atm is … Cabe, Trans. Am. Inst. Chem. Eng., 31, 129 (1935).]

…turated Sulfur Dioxide*

v_f, m³/kg	v_g, m³/kg	h_f, kJ/kg	h_g, kJ/kg	s_f, kJ/(kg·K)	s_g, kJ/(kg·K)	c_{pf}, kJ/(kg·K)	μ_f, 10^{-4} Pa·s	k_f, W/(m·K)
6.189.−4	12.602	7.4	433.3	0.033	2.212	1.280	12.3	
6.284.−4	5.946	9.1	446.1	0.041	2.159	1.284	10.6	
6.384.−4	2.376	28.6	453.8	0.123	2.075	1.288	8.37	
6.488.−4	1.605	43.5	459.5	0.198	2.001	1.293	7.03	
6.596.−4	0.9602	56.5	464.5	0.254	1.952	1.299	5.97	
6.707.−4	0.5864	70.0	469.7	0.308	1.906	1.308	5.11	0.262
[illegible]			474.5	0.363	1.865	1.317	4.39	0.243
						[illegible]	3.78	0.224

…urces

… and Gorelis, P…

15

Feb 19 2002

		50.00	50.00				
		KOH	H_2O	TOTAL	NaOH	H_2O	
KOH	100	65.15	34.85	~~652~~ 714	500	214	70%
				−66 ml 100 648	500	148	77.1
	125	68.1	31.9	−32 ml 150 616	500	116	81.2

M.P. 143

700 ml 500 H_2O 500 KOH
231

~~1200~~ 469 269 H_2O 500 KOH 65%

143 MP anhydrous.

700 500 H_2O 500 KOH
~~400~~ ~~266~~ 234 500 68%
125 434

Chemical Engineers Handbook Perry page 3-233 Enthalpy $\frac{454}{20.016} = 5.67$ $\frac{BTU}{Kcal} = 3.57$

70%	~~1~~50 F	66°C	320 BTU / lb.	56.4	14.2	~~0.03~~ 0.15
	212 F	100C	360	63.4	16.0	0.17V
	279 F	137C	400	70.5	17.7	0.19V
	302 F	150C	420	74.1	18.7	0.20V
	347	175C	445	78.5	19.8	0.21V

$2NaOH + SrCl_2 \rightarrow Sr(OH)_2 + 2NaCl$

1741 1978.2 2021 1714 -20.1

			158.52	36.032	Free water
$SrCl_2$ $2H_2O$	$SrCl_2$	H_2O	$SrCl_2$	$2H_2O$	H_2O
100	50	50	.315 mole. 50	11.4	38.6
120	53	47	.33	12.0	35.0
140	56	44	.35	12.7	31.3
160	58.5	41.5	.369	13.3	28.2
180	62	38	.39	14.1	23.9

$MgCl_2$					55.2 $MgCl_2$	Hydrated H_2O	Free water
100	42.3	57.7	$6H_2O$	108.096	.443	48.3	9.7
130	48.6	51.4	$4H_2O$	72.064	.510	36.8	14.6
150	51.8	48.2			.544	39.2	9.0
181.5	55.8	44.2	$2H_2O$	36.032	.586	21.1	23.1

94.2 2/54.6 109.2

2/46 = 92

Oct 22, 2003

Carbon To Hydrogen Test Cell

Cathode SS area $3\frac{1}{2} \times 2 = 7''$ .049 Anode Graphite 122 gms

Amps	1	2	3	4	5	6	7	8	9	10
Amp/sq ft	20.5	41	61.5	82	100.25	132	143.5	164.6	185.1	206
Per Hour Cg	.11	.22	.34	.45	.56	.67	.69	0.9	1.01	1.12
H_2 g	.02	.04	.075	.112	.15	.19	.23	.26	.33	.38
L/Hr	.2	0.4	0.8	1.3	1.7	2.1	2.5	2.8	3.7	4.2
ml/min	3.3	6.6	13	22	28	33	42	47	62	70

Solution = 400 mls H_2O 100g NaCl 90g NaOH 10g C 4g $CeSO_4$ H_2SO_4

Time	Temp	Open circuit	Amp	Induced Amp	Volts
136	106	50 mv	±0.1	0	0
145	107	50 mv		0	0
2:00	107	40 mV		1A	2V
203				2A	2.2V
				4A	3.5V Ramped up 0.2A
				0	0.2V
208	107			2A	2.5V
220	108			2.4A	2.5V
				0	0.4V (0.4 Amps)
				5.5A	1.5 - 0.1A fade Short circuit

70% Counter + the C - Ce for closed Oct 24, 2003

132	117	125mv	40mA	2A	3V 3½
134	145	0.5V	.05 MA	Off	
140	141	1.5V	3.5A	1 volts	
141	146	1.0V	3.8A	1 volts Closed circuit	
142	141	1.5V open	4.2A	1.0 0.5 Amps open circuit	
146	146	0.4	0.075A	0	0
10/10 at Random	147	148	0.5V 8A	8.5A 2V	0.7 Close Closed circuit
				2V	20 Amps

Oct 28 2003
[signature]

ReBuilt Cell Anode 138 gms Cathode 4x2 = 8 sq" 1A = 18 [illegible]

Heat up 80°C 0.7 [illegible] 5 Hot [illegible] - 0 - [illegible]
[illegible] 1 A [illegible] 0 [illegible] -5 -1
1:37 132 V 0 1.5
Rectifier off 37.5 mA @ 0.7V
4 volts 0.6A

← No [illegible]

125	220	1V	0.8A	1.5V	0.5
		1.5V	0.6A	2.0V	2.7
130		2V	4.4A	2.3V	5.3A
		3V	10.0	3.0V	
135	233	0	0	0.4	0.3A
		0.5	0.3	1.1	0.5
		1.0	~~1.5~~ 2.0	1.5	2.6
		1.5	3.8	1.8	5.9
		2.0	8.2	2.0	10.0
	243	0	0	0.2	0.2
135	247	0.5	0.8	0.9	4.1
		1.0	2.[illegible]	1.4	2.7
		1.5	4.[illegible]	1.8	5.0
		2.0	6.[illegible]	2.0	7.4
		3.0	12.5	3.0	15.5
		2.0	8.5	2.2	10.5
		1.5	6.5	1.8	8.1
		1.0	4.7	1.4	5.8
		0.5	3.1	1.0	4.0

0.1A / 0.2V	300	135	0	0	0.2
0.3A / 0.4V			0	0.9	0.4
0.8A / 0.5V			0.5	2.6	1.03
1.6A / 0.3V			1.5	6.3	1.87
2.1A / 0.2			2.0	8.3	2.26
3.1A / 0.1			3.0	13.7	2.5
			0	0	0.2 0.8A

Cell

				V	
125	Reading	30°C	0.7	.04 A
			0.4 V	0.3 A
135	0	0	0.2 V	0.2 A
			0.2 V	0.1 A
135	0.5	0.3	1.1	0.5
	~~1.0~~	~~1.5~~	~~1.5~~	~~2.6~~
	0.5	0.8	0.9	1.1
	0.5	2.6	1.0	3.4
	1.0	1.5	1.5	2.6
	1.0	2.1	1.4	2.7
	1.5	3.8	1.8	5.9
	1.5	4.1	1.8	5.0
	1.5	6.3	1.8	7.9
	2.0	8.2	2.0	10.0
	2.0	6.1	2.0	7.4
	2.0	8.3	2.2	10.4
	3.0	12.5	3.0	15.5
	3.0	13.7	2.9	16.8
Down	2.0	8.5	2.2	10.5
	1.5	6.5	1.8	8.1
	1.0	4.7	1.4	5.8
	0.5	3.1	1.0	4.0

CFRC

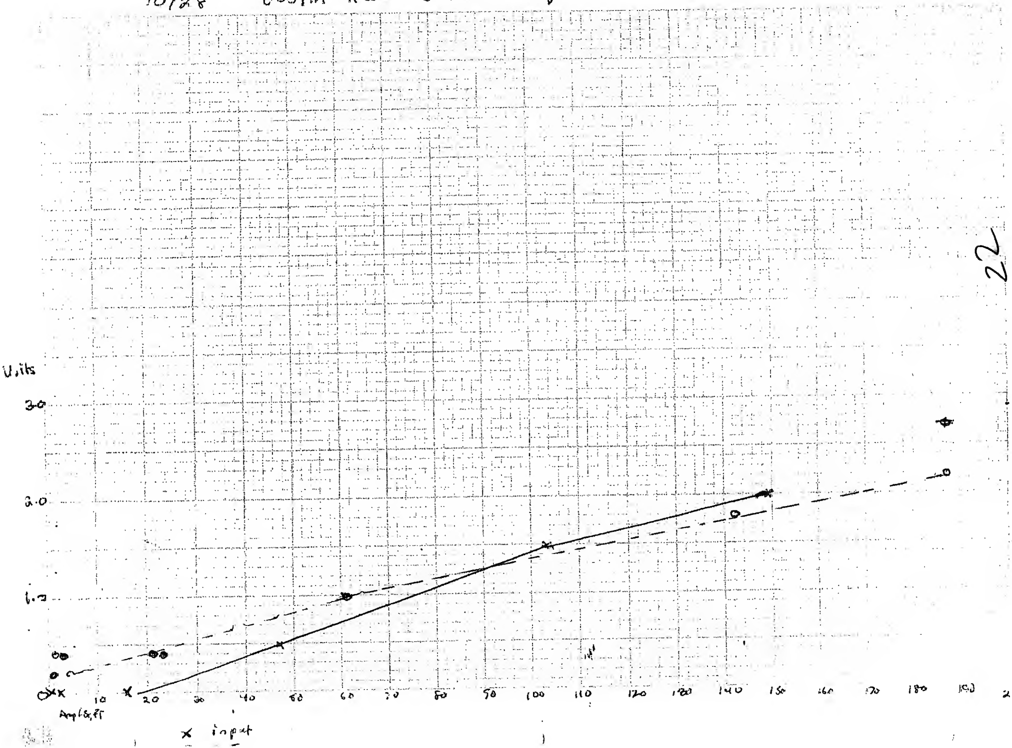
Oct 28 NaOH CeO_2 A.C.

Dec 11, 2003
[signature]

Input Output

0.0	0		0.7	.04	.03 >		+ .035
0 0	0		0.2	~~.02~~ 0.2	.04		
0.5	0.3	.15	1.1	0.5	.65	or	+ .45
or 0.5	2.6	1.3	1.0	3.4	3.4		+ 1.1
1.0	1.5	1.5 +1.25	1.5	2.8	3.9		+ 3.25
1.0	2.1	2.1 + .8	1.4	2.7	3.8		+ 0.4
1.5	3.8	5.7 4.2	1.8	5.9	10.6		+ 6.7
1.5	6.3	25 7.4 > 10.7 6.9	1.8	7.9 ~~10.~~	14.2		+ 11.4 6.8
2.0 ~~2.0~~	8.2	16.4 >229	2.0	10.2	20.4	> 219	
3.0	13.1 ~~12.5~~	39.3	3.0	16.1	48.3		

10/28 300 PM Run (no membrane) 135°C



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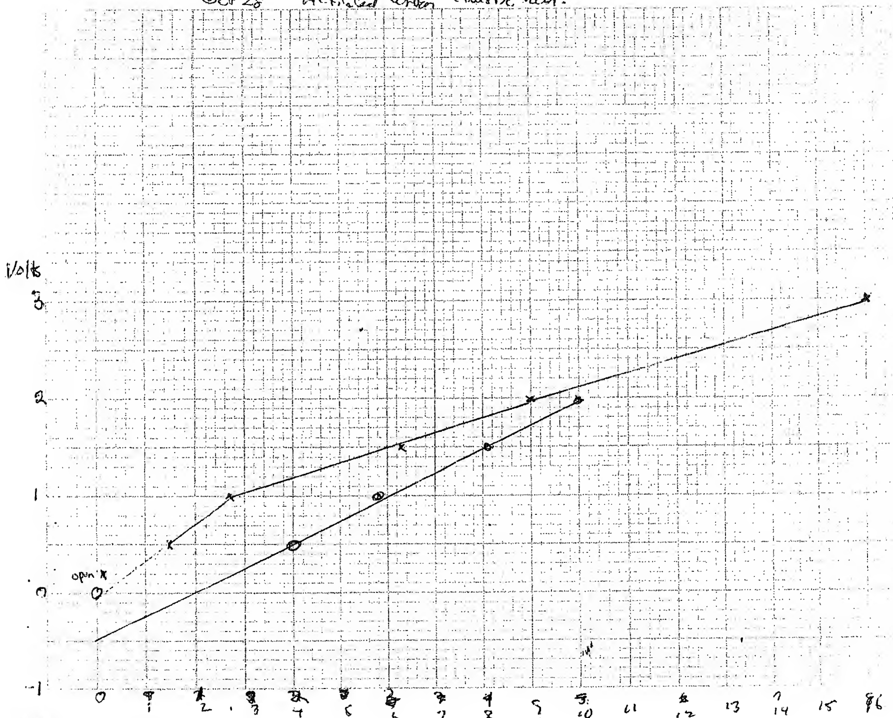
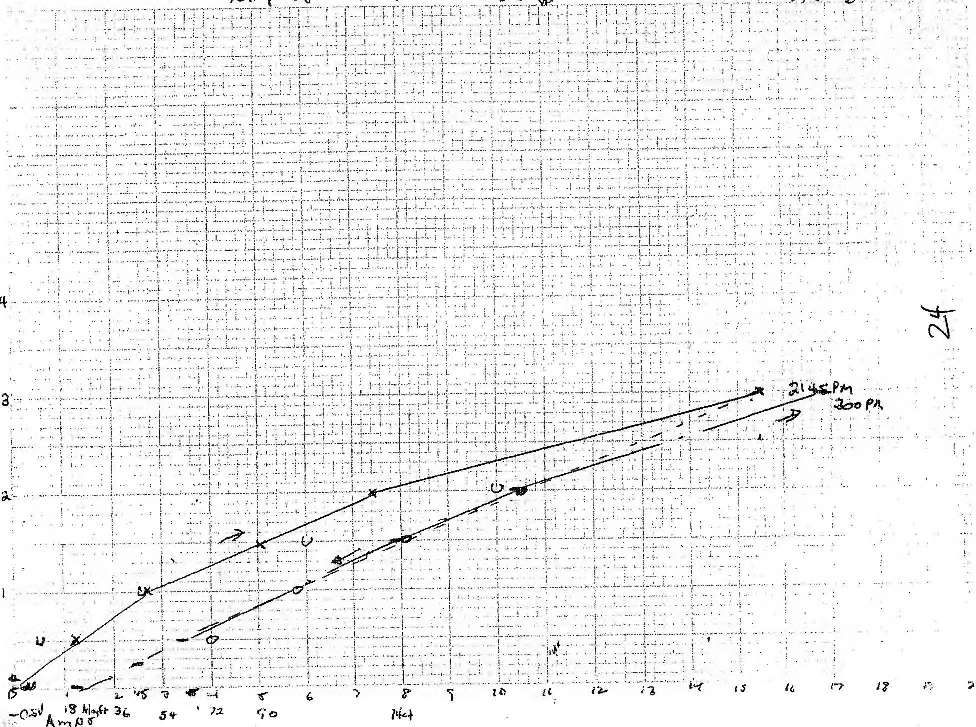
Oct 28 Activated Carbon Caustic Regn.



Oct 28 Temp 135C NaOH 92% Ceo₂ Catalyst

Paul R. Kruesi
Oct 29, 2003



Neo 12 7 aq NaOH + 300 ml H2O - 5 g Ac

160°C

Dec 11, 200

0	-0	0		0.5	.125	.06		
			> .05				> .16	+ .11
0.5	0.1	.05		1.1	.2	.22		
			> .35				> .29	= .06
1.0	0.4	0.4		1.3	.7	.51		
	>	>	1.55				> 1.87	+ .32
1.5	1.3	1.55		1.4	× 1.7	2.38		
			> 4.25				> 4.25	. 0
2.0	3.1	6.2		1.7×3.9		6.63		
			> 5.55				> ~~3~~.4	-2.15
2.5	4.7	11.75		1.7×5.9		10.03		
			> -5.55				> -3.4	+ 2.15
2.0	3.1	6.2		1.7	3.9	6.63		
			> -3.95				> -3.83	+ .12
1.5	1.5	2.25		1.4	2.0	-2.80		
			> -1.75				> -1.76	. 0
1.0	0.5	0.5		1.3	0.8	1.04		
			> -0.5				> -.54	-.44
0.5	0	0		1.0	0.1	1.0		

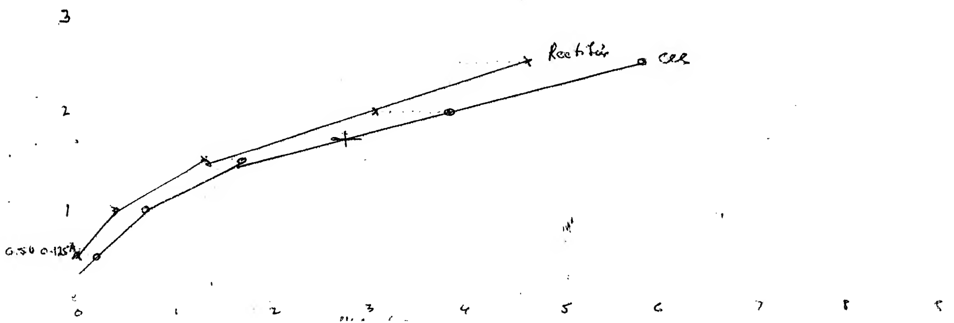
May 12, 2017
Paul R Koenig

700 gm NaOH 300 ml H_2O ~600 ml 5 gms Al

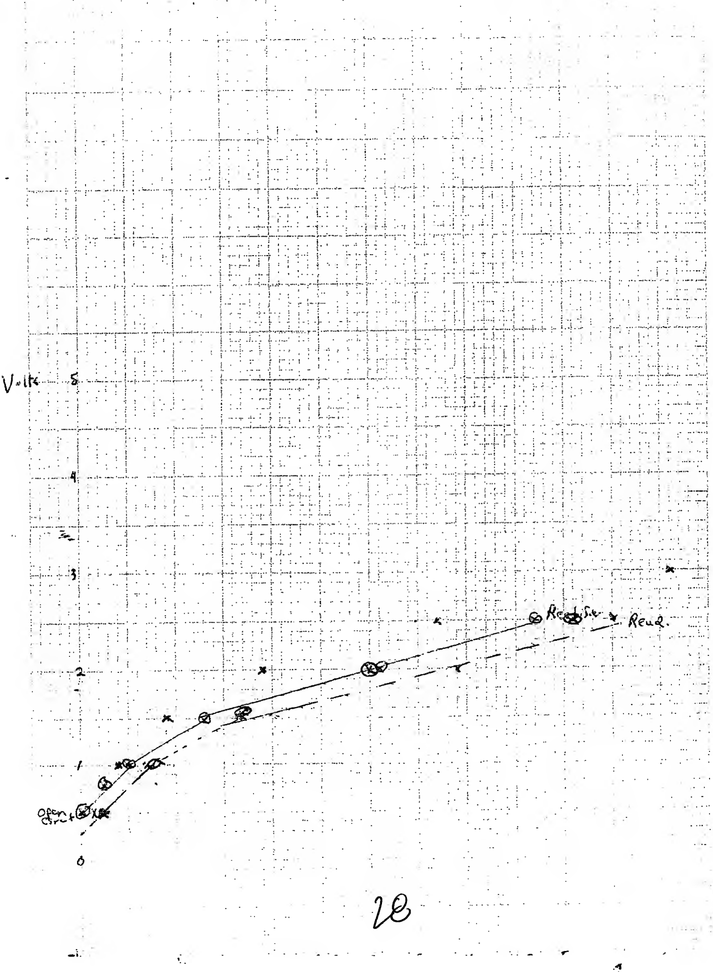
		~~Temp.~~ Reactor		Cell		I
Time	Temp	V	A	V	A	ΣA
218	150°	open circuit		0.55	0.1	
215	150	0.5	0.0	0.9	0.1	
		1.0	0.1	1.1	0.2	-0.2
		1.5	0.8	1.5	1.1	-1.0
		2.0	2.8	1.6	2.7	-2.5
		2.5	3.4	1.7	4.2	-4.2
		3.0	5.4	2.0	7.0	-6.8
		2.5	4.1	1.9	5.0	5.0
		2.0	2.4	1.7	2.95	2.95
		1.5	1.2	1.6	1.6	1.6
		1.0	0.5	1.4	0.1	-0.7
		0.8	0.0	1.1	0.0	-0.2 0.25
		0.8	0.0		falls	-0.1 -0.2
243	160	open circuit		0.56	0.125 A	
		0.5	0.1	1.1	0.2	-0.2
		1.0	0.4	1.3	0.7	-0.5
		1.5	1.3	1.7	1.7	-1.5
		2.0	3.1	1	3.9	-3.8
		2.5	4.9	1.7	5.9	5.8
		2.0	3.1	1.7	3.5	-3.8
		1.5	1.5	1.4	2.0	-1.9
	175	1.0	0.5	1.3	0.8	-0.7
		0.5	0.0	1.0	0.1	0.1 0.25

open circuit 0.5 0.1 to 0.125 G.R. Faddis

11/12/03 NaOH 70% 5g Activated Carbon
160°C



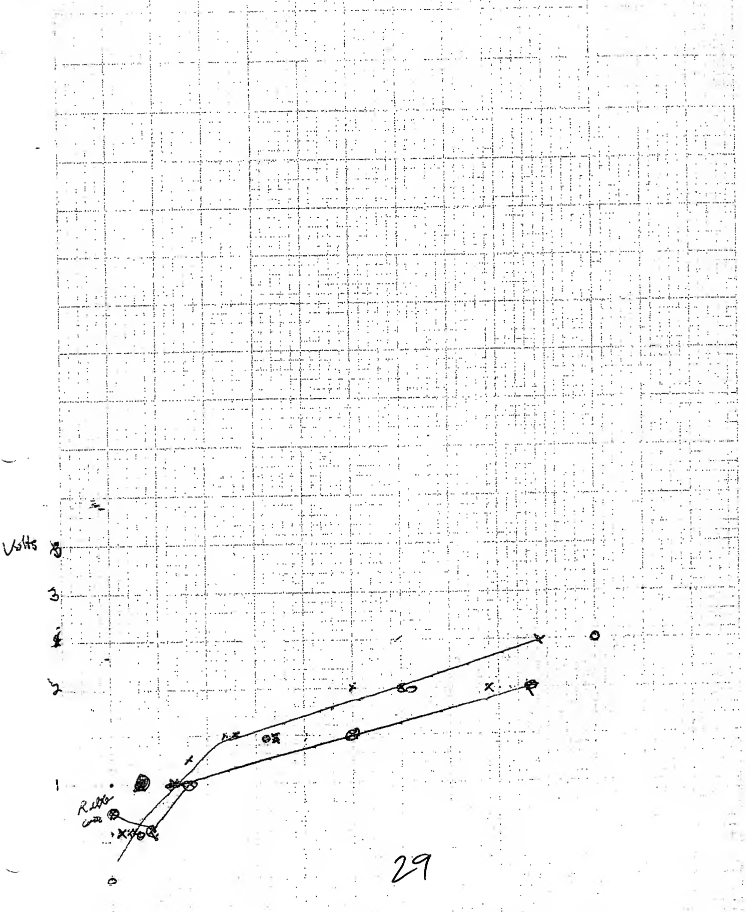
Coustic +160° to 178c X Noo14



28

Neod with CeO2 AC Nov 14 2003

155°C



29

Previous Run NaOH Carbon Cell 2x2½ x29

47
38

28 8 gms of wax + 30 gms $NaHCO_3$ + 100 mls H_2O
+10 gms $NaHCO_3$
+20 gms

Reaction occurs at 60°C - Vigorous at 80°C - CO_2↑
water out 46 gms of spperfied + crystallizes to white ~~mtrl~~ in cool

Used old Ceria Catalysed Carbon poles 7% CeO_2 Fuel Cell 0300 1430.
Temp 155C open circuit V 0.6V Amp = 0.6 0.15 Amp
Reads 0.1 Amp

.8
.7
15

Time	Temp	Rectifier V	Rectifier A	Reading Volts	Amp	- Amps
250	160C	0	0	0.6	0.15	
253				0.65	0.175	
303	157C	0	0	0.68	0.175	
		0.5	0.1	1.0	0.2	-0.2
		1.0	0.2	1.2	0.4	-0.4
		1.5	0.3	1.3	0.5	-0.4
		1.5	0.7	1.4	0.9	-1.0
		2.0	1.5	1.5	1.9	-1.8
		2.5	3.0	1.6	3.7	-3.6
		3.0	4.9	1.8	+6.2	-6.2
		2.5	4.2	1.72	5.2	5.1
		2.0	2.6	1.6	3.0	-3.1
		1.5	1.4	1.5	-1.7	-1.7
		1.0	0.5	1.3	0.7	-0.7
		0.5	0.0	1.0	0.1	-0.1
					0.25	
open 08				0.8	0. 0.175	

Iron Carbon Cell

Nov 3, 2003
Frank K[illegible]

ZnCl2 85% ZnCl2 -
add 50 grms Fe(OH)3 + 5g Al

Anode + Cathode = 2" wide 3½ Tall - ½"

No Fe - Carbon open circuit 11 ohms resistance

		Battery V	A	cell Cell V	A
				1.5	0.2A
2½	150°C	~~0~~ 1.51	~~0~~ 0.1	~~1.5~~	~~0.1A~~
		2V	0.3	2.0	0.5
		3V	1.7	3V	2.1
		4	2.5	3.6	3.1
		5	3.8	4.7	4.6
		4.5	3.7	4.7	4.6
	Temp 145	4.0	3.4	4.4	4.2
		3.0	1.9	3.3	2.6
		2.0	0.8	2.6	1.0
		1.0	-0.2	1.65	-0.3
	off	2.0	-0.1	1.60	-0.3
	Temp 143	0.5	-0.1	1.1	-0.1
		1.0	0	1.5	0.1-0.2
		2.0	0.6	2.4	0.8
		3.0	1.4	3.3	1.8
		4.0	2.4	4.28	3.0
		5.0	3.5	5.2	4.3
		6.0	4.4	6.0	5.5
		7.0	5.7	7.0	7.1
		6.0	4.6	6.0	5.6
		5.0	3.7	5.0	4.5
		4.0	2.6	4.4	3.3
	131	3.0	1.5	3.4	1.9

Oct 28 Temp 105C Naoq 128 CeO2 Catalyst Oct 28, 2003

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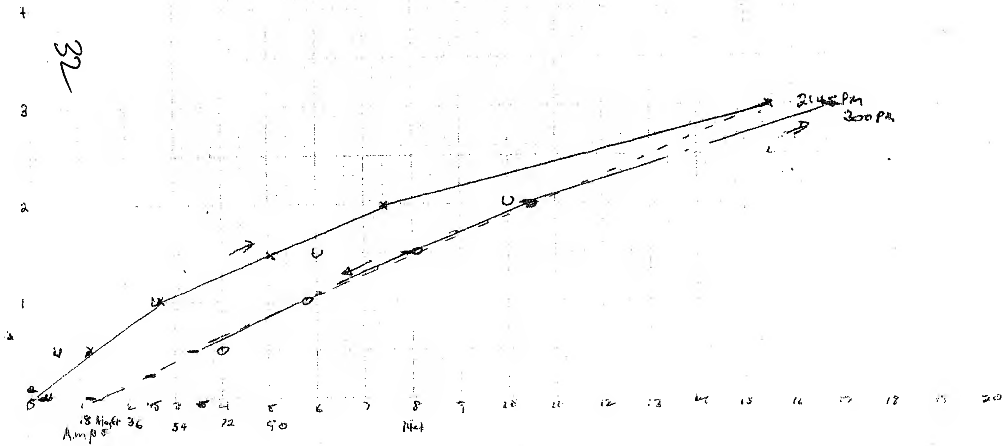
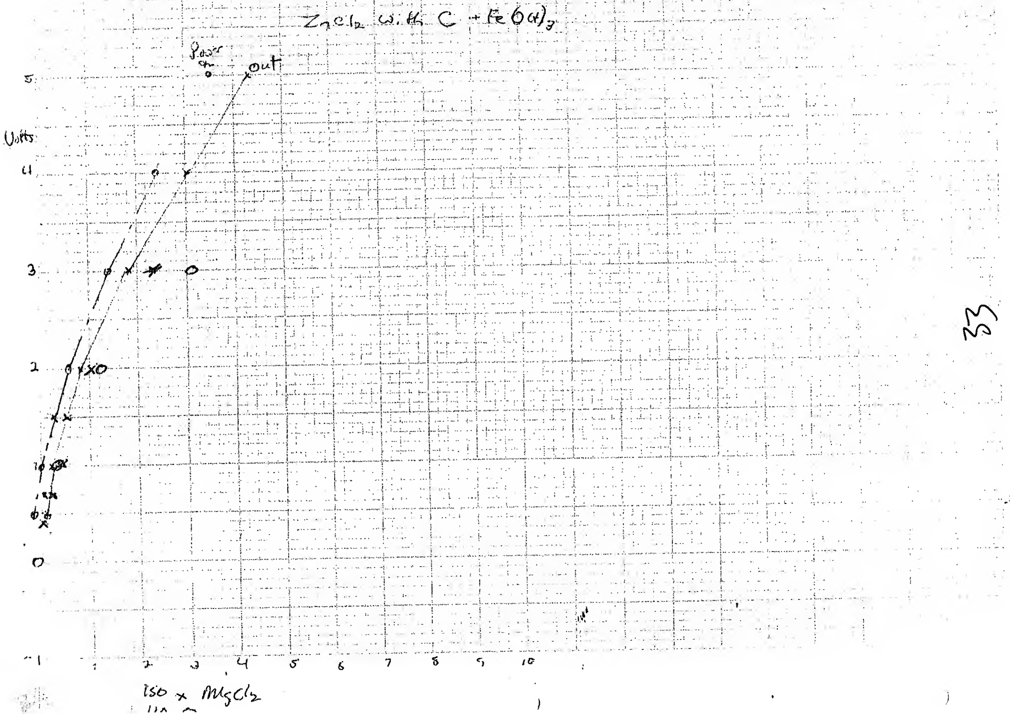


Nov 3 2003



$ZnCl_2$ with C + $Fe(OH)_3$
Units
Poor
out
5
4
3
2
1.0
0
-1
1
2
3
4
5
6
7
8
9
10
150 x $MgCl_2$

33

$SrCl_2$ - 40g KOH & Acc

June 11, 2003

[signature]

Temp 105 opps

0	0	0	0.7	0.1	.07		+.07
0.5	0	0	1.3	0.2	.26		+.26
1.0	0	0 >.3	1.5	0.2	.30	>.5	+.2
1.5	0.2	.3 >1.3	2.0	0.4	.80	> 1.73	+.43
2.0	0.8	1.6 >8.6	2.3	1.1	2.53	1007	+1.4
3.0	3.4	10.2 >17.8	2.8×	4.5	12.60	> 16.6	−1.2
4.0	7.0	28.0 >−15.1	3.4	8.6	29.2	> −14.1	+1.0
3.0	4.3	12.9 >−9.3	2.8	5.4	15.1	−9.8	−0.5
2.0	1.8	3.6 >−3.15	2.4×	2.2	5.3	> −4.5	−1.35
1.5	0.3	.45 >−.45	2.0×	0.4	0.8		
1.0	0	0	1.6	0			
0.5	−0.1		0.9	−0.2			

34

Anode + Cathode 3"x2" 6 sq"   Nov 6, 2001

Anode Carbon = 117 gms ZnCl2 K04 Frank Keen

930 30 ohms at 50°

950 - 0.5V 30 ohms No amps. add 15g Urea

754 60°C 50 ohms 0.5V .01 Amp 25/250

400 mls = 600 ml H2O

1006 50C 60 ohm 0.5V .01 Amp

+100 H2O

1010 50C 40 ohms 0.6V .0016 Amp
+100 H2O

1020 40C 35 ohm 0.65V .0016 Amp

1034 50C 45 ohm 0.4V .001 Amp
+100 H2O

1040 50C 45 0.7 .007 Amp

257 out

1050 +40 gms salt 4 0.4V .0016 Amp
add 5g 400 ohm one sqrt of drill

1054 50C 350 ohms 0.5V .02 Amp

1103 60C 30 ohm 0.5V .02 Amp

Shut down

1:30 35C 350 ohm 0.4V 0.0? Amp

140 55C 30 0.4V 0.016 Amp

153 78C 20 0.5 0.07 0.5 ohm

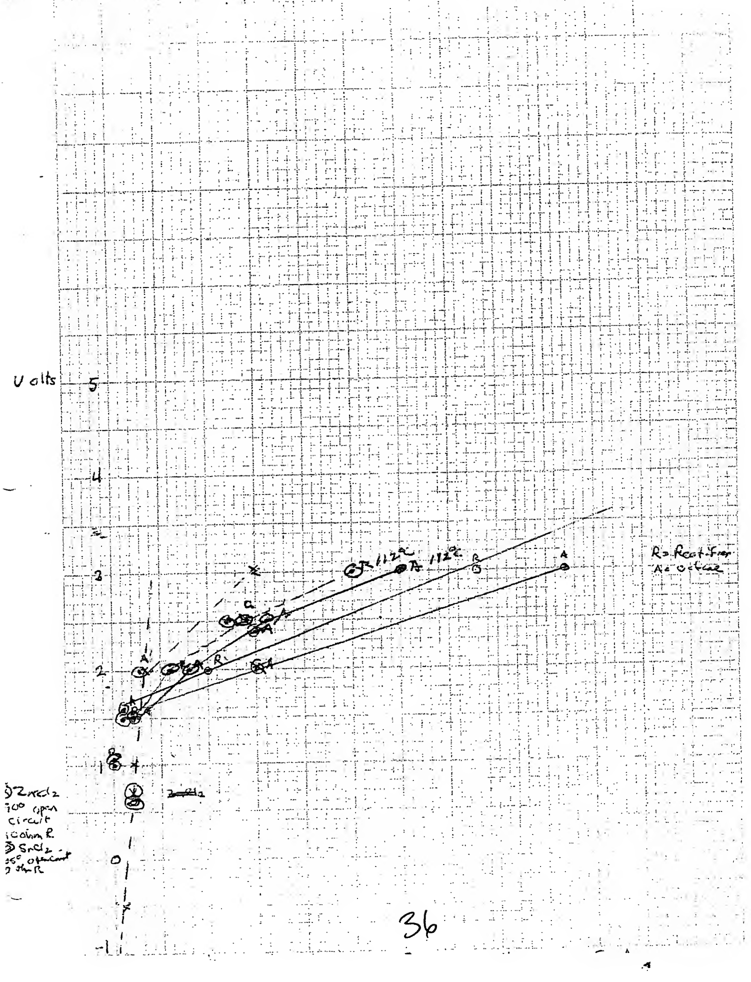
205 90°C 4 1.0 + .25A

210 85°C

226 95C 10 ohm 0.7V 0.2A

		V	A
0.5V	0	1.0	0.2
1.0	0	1.4	
1.0	0	1.3	0.23A
1.5	0.1	2.0	0.3A
2.5	0.4	2.2	0.6A
3.0	1.2	2.9	2.9A
1.0	0.0	1.5	+.25
2.0	0.2	2.1	0.35
3.0	1.2	2.4	1.5
0.5	0.0	1.0	0.1
1.0	0.0	1.4	0.2
2.0	0.3	2.0	0.5
3.0	1.3	2.4	1.7

$Fe(OH)_3$ + $ZnCl_2$ or $SnCl_2$ (Dec 11, 2003



[illegible]
Nov 7, 2003

Strontium Chloride 500 mls HCl Conc + 300 g $SrCO_3$
pH 2.5 add 40 g $Fe(OH)_3$ 5 g C

Temp	Reading	Volts	Amps		V	Amp	V	Amp	+
150	103	0	0.3	.05	0.5	0	1	0.1	+
					1.0	0.1	1.5	0.1	-0.2
					1.5	0.2	2.0	0.2	-0.4
					2.0	0.8	2.3	1.1	0.8
					3.0	3.2	2.8	4.7	foaming
203	105 off	0	0.7	0.1	0.5	0	1.3	0	-.2
					1.0	0	1.5	0	-.2
					1.5	0.2	2.0	0.4	0.4
					2.0	0.8	2.3	0.1	[illegible]
					3.0	3.6	2.8	4.5	[illegible]
					4.0	7.0	3.4	8.6	2.5
					3.0	4.3	2.8	5.4	5.4
					2.0	1.8	2.4	2.2	2.2
					1.5	0.3	2.0	0.4	-0.4
					1.0	0	1.6	0	-0.2
					0.5	-0.1	0.8	-0.2	-0.4
220	105	0	0.6	0.1A	off	Cl			
					0.5	0	1.1	0.1	
					1.0	0	1.5	0	-0.1
					1.5	0.2	2.0	0.3	-0.3
					2.0	0.8	2.3	0.1	-0.8
					2.5	2.3	2.7	2.8	-2.8
					3.0	3.8	3.0	4.7	-4.7
					2.0	1.6	2.4	1.5	-1.5
					1.50	0.1	2.0	[illegible]	[illegible]

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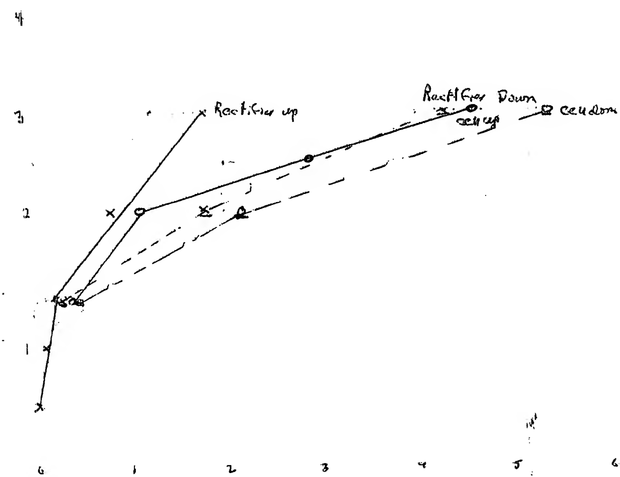
$SrCl_2$ Media $Fe(OH)_3$ agen Hg   Sj Activated carbon   Nov 8-10

Temp = 105°C

Open Circuit   0.7 Volt   0.1 A.



$SrCl_2$ Fe(OH)$_3$ Continued

9 9 3/8 = Top 4 3/4 G volts

1418 Cathode 206 Anode 112 gms
106 + 5g Ac Out 079 gms
1059 ξ^{45} 113°c H_2O ~~std~~ out
Volume loss ~ 200 ml @ 110°c

Fred Kuni
Nov 10, 2003

$2SrCl_2 2H_2O + C \rightarrow 2SrCl_2 \cdot H_2O + CO_2 - 2H_2$

used 36 g Fe(OH)$_3$

	Reactor	Volts	V	Amp	V	Avg	Anode
1053	111°C	0	0.3				
1050	111°C		0.35 0.4	0.5	0	0.5		
				1.0	0	1.5	0.1	-0.2
				1.5	0.1	2.0	0.2	-0.3
1112	112°C			2.0	0.3	2.5	0.4	-0.6
				2.5	0.8	2.75	1.0	-1.1
				2.0	0.4	2.5	0.7	-0.5
				1.5	0.2 0.15	2.1	0.3	-0.3
				1.0	0.0	1.5		
				off	0	0	0.8	-0.1
							greater 0.5	
					add water		0.6 V	.005 A
1127	111C			0.5	0	1.25	~~1.25~~ 0.1	0.0
				1.0	0	1.6	0.1 0.2	.05 0.1
				1.5	0.1	2.0	0.2	-0.1
				2.0	0.6	2.5	1.0	-0.8
							1.1	-0.9
				2.5	1.4	2.9	1.9	-1.8
				3.0	2.4 ~~3.0~~	~~2.3~~ 2.4	3.0	-2.9
				3.0	2.5 ~~2.5~~	3.3 3.8	3.0	-2.8
				3.0	2.3	3.9	2.8	-2.6
				2.5	1.2	~~2.8~~	1.8	-1.8
				2.0	0.6	2.4	0.8	-0.7
				1.5	0.0 0.1	2.0	[illegible]	[illegible]

39

Continued

Nov 14, 2003

			Rectifier		Cell	Amps		
319	155		0.5	0.2	1.1	0.3	-0.3	
			0.5	0.0	1.0	0.1	-0.15	
			0.75	0.1	1.12	0.2	0.2	
			1.0	0.5	1.3	0.7	-0.6	
326			1.5	1.0	1.4	1.3	-1.2	
		Rectifier current	1.3	1.0	1.4	1.3	1.2	
		(1.1)	1.5	4.4	1.5	1.2	-1.6	
		(1.3)	2.0	2.4	1.6	3.0	-3.0	
		(1.1)	2.5	3.6	1.7	4.4	-4.4	
		(1.1)	2.0	2.0	1.6	2.5	-2.5	
		(1.3)	1.5	1.0	1.5	1.2	1.2	
		(1.5)	1.25	0.5	1.4	0.7	0.7	
		(1.5)	0.5	0.0	0.68	0.0	0.1	Reads more than 0.25A
		0	0	0	0.8			0.175 A

Mgele C Moler [signature]

Deleted From Memo 12/03/03

		Mgn	½ Mg	Cell	Amp	−Amp
open circuit		✓		✓		
110e	0.3	~~0~~	~~0.12~~	~~6.7 6.8~~	~~1.0~~	0.8
		0.50	0.50	0.7	0.5	0.1	−0.2
		1.1	0.9	0.05	1.0	0.1	−0.3
		2.0	0.9		2.2	1.2	−1.2
		3.0	2.0		3.3		−3.3

Open 1.1 [illegible] 0.7

0.7 volts .12 Amp

Ml_2Cl_2 MnO_2 12/03/03

V	A	~~[illegible]~~				
0	0	0.5	150			
		0.4	150 off scale			
		0.2	110			
0.5	0.1-0.2	0.8	145	mA 0.3	0.1	-0.2
		1.0	150		-0.1	-0.2
		1.2	down			
		0.5	0.6 110		0.1	-0.2
1.0	0.0	1.45	150C		0.0 / 0.4	-0.1 / -0.3
1.0	0.2 ~~0.3~~	1.4	145		~~0.2~~	
Down 1.0	0.0	1.4			0.0	-0.2
1.5	0.3	1.9			0.5	-0.5
Down 1.5	0.0	1.9			0.0	-0.3
2.0	0.8	2.1			1.1	-1.0
Down 2.0	0.3	2.3			0.4	-0.5
2.0	0.3	2.2			3.7	-0.3
110 2.0	1.2	2.2			0.8	-1.2
3.00	2.0	3.0			2.4	-2.2
3.0	0.2	3.0			0.4	-0.2
110 3.0	2.6	3.3			3.3	-3.3

.25
.15
1.25
.25
3.75

Anode a-5X2

Carbon Fuel Cell

$MgCl_2$ 47.4% 700 ml

MnO_2 40g AC 5 gms Used salt 7 ohms

Dec 3, 2003

	Every Gly In		Mg Water V	Cell V	Cell A	Img V	Img A	Anode A
Temp 130C	10 45	V 25 mV, A .025A						
	OPEN C 0.2V							
145C	1053 -		0.75V	.98V	.3	0.5	0.1	-.2
			1.3	1.5	0.4	1.0	0.2	-.3
			1.8	2.0	0.5	1.5	0.3	-.5
			2.1	—	1.1	2.0	0.8	-1.0
			3.0	-	2.4	3.0	2.0	-2.2
			2.3	,	0.4	2.0	0.3	-0.5
			1.8	1.9	0.0	1.5	0.0	-0.3
			1.4	1.4	0.0	1.0	0.0	-0.2
			1.0	1.0	-0.1	0.5	0.0	-0.2
150C	11 10	Open circuit	0.4	0.4	-0.2	0.0	0.0	-0.1
		feed gas	.05V	.001	~~.045~~ mV			
		.037 A at	0.5	0.5	0.0	0.0	0.0	
		0.3A	1.0	1.1	0.0	0.5	0.0	-0.1
			1.4	1.5	0.0	1.0	0.0	-0.1
		+0.25A	1.8	1.9	0.1	1.5	0.0	-0.2
			2.2	~~2~~	0.25	2.0	0.1	-0.3
			3.0		0.4	3.0	0.2	-0.2 Smell Cl_2
		+0.25A	2.5		0.1	2.0	0.0	-0.1
			2.0		+0.05	1.5	0.0	-0.05
	43	+0.25A	+1.6	1.5	0	1.0	0	0
			1.2	1.2	~~[illegible]~~	0.5	0	

Carbon Fuel Cell

Dec 2 2003

Old Coconut ~ 700 mL - 100g NaOH

10g Rubber NW Dec 1, 2003

250	Temp	Time	Volts	Volts	Amp	Amps	Volts	
.7 / 135	140	120	0.6	0.65	.16	0	0	
			0.8		.25	0	0.5	
		130	1.2	1.4	.5	0.3	1.0	-0.4
			1.8	1.4	1.7	1.4	1.5	Foaming
		135	0.55	0.6	0.16	0.10	0	-0.1
			1.5		3.0	1.4	2.0	-3.2
					4.1	2.1	3.0	
			1.5		3.8	3.2	2.6	-4.0
			1.86	1.5	~~2.1~~	1.8	1.5	-2.3
			1.4	1.3	0.7	0.5	1.0	-0.6
			0.9	1.0	0.1	0.0	0.5	-0.1
		open ckt	0.7	0.65		0.0	0.0	
		closed	0.3	0.1				
		150	1.0	1.0	0.4	0.3	0.5	-0.2
			1.5	1.3	0.8	0.6	1.0	-0.7
			1.9	1.5	2.5	2.0	1.5	-2.4
				1.3	4.3	3.5	2.0	-4.1
					4.1	3.3		
		Open circuit						
		130	0.6	0.6	0.16	~~00~~		
		123	0.49	0.5	0.15			
		120	0.47	0.5	0.125	carbon in no spit		
		110	0.46	0.5	0.125			
		108	0.46	0.4	0.125			

CFFC

Fuel Cell Carbon

Dec 10, 2003

[signature]

To Dec 4, 2003 Rubber (MW) Carbon add 5gms

MW Rubber Carbon of Dec 1, 2003

Cell volts .08	Amp Ac		Hydrogen V	A	Temp	V	My volts V	Output A		
0	0	145PM	0	0	50°	0.7	0.9	0		
0	0	155	0	0	90°	0.73		0		
0	0	200	0	0	100	0.6	.65	0		
1.0	0	207			110	0.58	0.6	0.3-0.4A	0.1	add Rubber
0.5	0	215	0.5	0	120	0.7	0.7	0.38		
								+0.1 -0.1A	Amps	
1.0	0		1.0	0.4		1.35		0.2 -0.1	0.4	
			1.5	0.8				1.1 -1.1		
					135				from cell fluxes	
0.0		237	0.0		135	0.5	0.5 0	0 0	.25A	
			0.5	.0		0.8	~~1.2~~	0.2-0.1	.25A	
			1.0	0.2 0.1			1.2			
			1.5	1.3		1.4	1.5	1.8 -1.6		
			2.0	4.3		~~1.5~~	1.5			
0			1.5	1.4				1.8 -1.7		
			2.0	4.0		1.6		4.9		
		250 PM	1.0	0.2		1.1	1.2	0.3 - 0.3		
		~~135~~	1.5	1.1	135	1.5	1.5	1.5 -1.4		
			2.0	3.0		1.6	1.6	3.7 -3.6		
			2.5	4.4		1.7	1.7	5.2 5.1		
			2.0	2.0		1.5	1.6	2.5 -2.4		
			1.5	0.7		1.3	1.4	1.0 -0.9		
			1.0	0.1		1.1	1.2	0.4 0.3		
			0.5	0.0		0.8	0.85	0.1 0.0	Read 0.16A	
			0.0	0.0		0.7	0.65		0.12A	

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C EFC

Page 2

Dec 10 2003

[signature]

A 307 137 0.6 0.6 0 0

	3.0	7.0				
	0.5	0.0	0.9	1.0	0.15	0.0
	1.0	0.3	1.2	1.3	0.5	-0.4
-0.2	1.5	1.5	1.4	1.5	2.0	-1.9
-0.2	2.0	2.4	1.5	1.6	2.9	-2.8
-0.4	2.5	3.3	1.6	1.6	4.2	-4.0
-0.2	3.0	4.4	~~0.8~~	1.7	5.4	5.3
		4.7	Gelcard		5.5	
	2.5	2.5	1.6	1.6	3.2	3.3
	2.0	1.6	1.5	1.6	2.1	2.0
	1.5	0.8	1.4	1.5	1.1	1.1
	1.0	0.1	1.2	1.3	0.3	0.3
	0.5	0.0	1.0	1.0	0.2	-0.1
	0.0	0.0	0.8	0.8	0.0	0.0 0.15

	A/sqft	A/sqcm	0.3 A/qcm
24 x .15	3.6	÷ 929	280 Asqft
24 x .5	12		11.6A
24 x 2	48		

Paul R Kraus [signature]

12/10/03 px² In Out

Amp Volts	External V	A	Power watts		Cell V	A	Power	+ gain -L
	0		0		0.6 V	0.15 A	.09 watts	>+.06
20V .001 0.3	0.5	0.0	0	>0.3	1.0	.15	.15	> +.48 + .18
	1.0	0.3	.3	>1.5	1.25	0.5	.63	> 2.27 + .32
.01 2.25	1.5	1.5	2.25	>2.55	1.45	2.0	2.90	> 1.60 -1.0
.02 4.8	2.0	2.4	4.8	>3.45	1.55	2.9	4.50	> 2.22 -1.23
.033 8.25	2.5	3.3	8.25		1.6	4.2	6.72	> 2.46
.063 13.2	3.0	4.4	13.2	>5.95	1.7	5.4	9.18	> -4.06 + .89
	2.5	2.9	7.25	>-4.05	1.6	3.2	5.12	> -1.86 + 2.19
	2.0	1.6	3.20	>2.0	1.55	2.1	3.26	> 1.66 + .34
	1.5	0.8	1.20	>1.1	1.45	1.1	1.60	~~1.5~~ -1.22 -.12
	1.0	0.1	.10	>-0.1	1.25	0.3	0.38	> -.18 -.08
	0.5	0	0		~~0.8~~	0.2	0.2	> ~~.07~~ -.05
pr.	0.0	0	0.8		0.8	.15	.012	-
2.37 ~~2.08~~ 135	0.0	0	0	>0	0.5	.25	.125	> ~~.48~~ 0.105 -.16
	0.5	0	0	>.2	0.8	.25	.2	> .2 0 c
	1.0	0.2	0.2	>1.45	1.3	.3	.4	> 1.85 + .45
	1.5	1.1	1.65	>4.35	1.5	1.5	2.25	> 3.67 - .68
	2.0	3.0	6.0	>5.0	1.6	3.7	5.92	> 3.77 - 1.23
	2.5	4.4	11.0	>-7.0	1.7	5.2	9.69	> 5.54 + 1.06
	2.0	2.0	4.0	>-2.25	1.5	2.5	3.75	> -2.4 - .15
	1.5	0.7	1.75	>-1.65	1.35	1.0	1.35	> -.89 - .76
	1.0	0.1	.1	>-0.1	1.15	0.4	.46	> -.332 - .28
	0.5	0	0		0.8	0.16	.128	> -.044 - .04
	0.0	0	0		0.7	.12	.084	

CFRC 12/12/03

Feed 10g NaOH/C Carbon to Rubber [signature]
NaOH From 12/12/03 Am Filtered

Open Cathode Anode

Time	Temp	Volts		Readings V	Readings A	Reading		
237	100°C	0.6	off	V	A	V 0.7	A .15	
243	118	0.3	on	0	0	work boiled up + rubber off		
250	120	0.3	on	0.	0	0.8	.1	
255	120	1.1		0.5	0	1.0	0.1	0.15
		1.5		1.0	0	1.1	0.1	0.25
258		—		1.5	0.2	1.4	0.4	-0.4
				2.0	1.4	1.6	+1.9	-1.8
				2.5	2.8	1.9	3.3	
				3.0	5.0			
				2.5	3.2	1.7 →	3.6	
				2.0	2.5		1.6	2.1
		1.5		1.5	0.6	1.5	0.9	0.
		1.4		1.0	0.1	1.3	0.3	
311	120°			3.0	5.1	1.8	6 - 6	
		2.0		1.5	1.1	1.8	1.4	
328	123	0.6	off	0	0	0.7		0.120
337	125	0.5	off	0	0	0.6		0.1
345	127	0.5	off	0	0	0.6		0.1
		0.4	on	0	0	0.5		0.1
		1.0		0.5	0.1	0.9		0.2
		1.5		1.0	0.45	1.3	0.4	
				1.5	0.8	1.5	1.0	
		48		2.0	1.2	1.6	1.6	

CFRC

121 page 2 12/12/03

[illegible]

		Cell			ce	Coke	Amp	
1109	off	0	0	130	0.4	~~0~~ 0.5	0.15	all below of coiled coil
1111	on	0.5	0.1	130	~~0~~.1	1.0	0.3 -0.2	
		1.0	0.2		1.5	1.2	0.4 -0.4	
		1.5	0.7		1.9	1.6	1.0 -0.9	
		2.0	1.6		—	1.5	2.2 -2.0	
		2.5	2.7		—	2.3	3.5 -3.3	
		3.0	4.1				+5.7	
		2.0	2.0			2.0	2.6 -2.4	
		1.5	1.2			1.8	1.6 -1.4	
		1.0	0.3			1.5	0.5 -0.4	
		0.5	0.0		1.0	1.0	0.1 -0.1	+0.25

12/11/03 CFFC

Cathode 208
Anode 131

Diaphragm (Nafion) Cell

Reuse Cathode + Carbon (Rabbo Cavalcate) from 12/8/

Time	Temp	Resistor	Volt	Amps		Diaphragm V	Amp	Volts	Amps
1000	40		0.05						
1013	100	4 ohm	0.05	0.01					
1015	110	5 ohm	0.1V						
1023	120	5 ohm	0.1V			0.5	0	0.8	0.2
						1.0	0.2	1.7	-0.5
1029	130				Line 0.5	1.5	1.0	2.2	-2.1
						0.2	0		
1035	130				Line	0	0	0.6	0
					0	1.0	0	1.0	0.5
1040	127				-0.2	1.5	0	1.3	-0.2
					0	2.0	0.5	1.7	-1.1
						2.5	1.0	2.0	-2.4
					-0.2	3.0	2.0	2.4	-3.9
						4.0	8.0	3.0	-9.0
Change Polarity					-0	0	0	0.8	0.21
1155	130		0.6			0	0	0.6	.15A
			1.0			0.5	0	0.2	0.9
			1.4			1.0	0.18	0.3	1.2
			1.9		phizzled	1.5	0.7	1.6	1.6
			2.0			2.0	1.4	1.5	1.5
						2.5	2.5	2.3	2.3
						2.0	1.9	2.0	2.4
			1.9			1.5	1.1	1.8	1.4
			1.8			1.0	0.3	1.5	0.5
			1.1			0.5	0.0	1.1	0.1
			0.8			0	0	0.8	0
			0.5						

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Time 356 Temp 125

Rectifier V	Rectifier A	Red	V	A	
3	4.1	–	1.8	5.1	
2.5	3.4		1.8	4.2	
2.0	2.1		1.7	2.6	
1.5	1.1	1.5	1.6	1.5	
1.0	0.25	1.5	1.5	0.4	
0.5	0.1	0.9	0.5	0	0.22

Rezzy P 12/12

Northwllass 11/11/c

MW Rdber Rectifier V	A	Cell out V	V	A		193-127 V	A	V	V	A
0	0	0.6	0.6	0.15	~~0.7~~ 1.5	0	0	0.4	0.5	0.1
0.5	0	1.0	0.2	0.9	0.9	0.5	0.12	1.0	0.9	0.3
1.0	0.1	1.4	1.3	1.2	0.9	~~1.0~~	0.15	1.5	1.3	0.4
1.5	0.7	1.9	1.5	1.6	1.0	1.5	0.7		1.5	1.0
2.0	1.4	2.0	1.9	1.9	2.2	2.0	1.2	–	1.6	1.6
2.5	2.5		2.2	3.2	3.5	2.5	2.6	–	1.7	3.5
2.0	1.9		2.0	2.4	2.6	2.0	2.1	–	1.7	2.6
1.5	1.1	1.9	1.8	1.4	1.6	1.5	1.1	1.9	1.6	1.5
1.0	0.3	1.5	1.5	0.5	0.5	1.0	0.25	1.5	1.5	0.4
0.5	0.0	1.1	1.1	0.1	0.25	0.5	0.1	0.9	0.9	0.27
0.0	0	0.8	0.8	0.0	0.2 → 0.16					

32, 5.7 out

121

129 sq cm / layer

6.452

8.755

1.4X

$2\frac{1}{2} \times 3\frac{1}{2}$

54.7 sq cm

5 0.09

4 0.07

3 0.05

2 0.036

1 0.018

85%

80Fc 0.35 1000

0.2 500

PEMC 1 A/cm²

Electro Compatible

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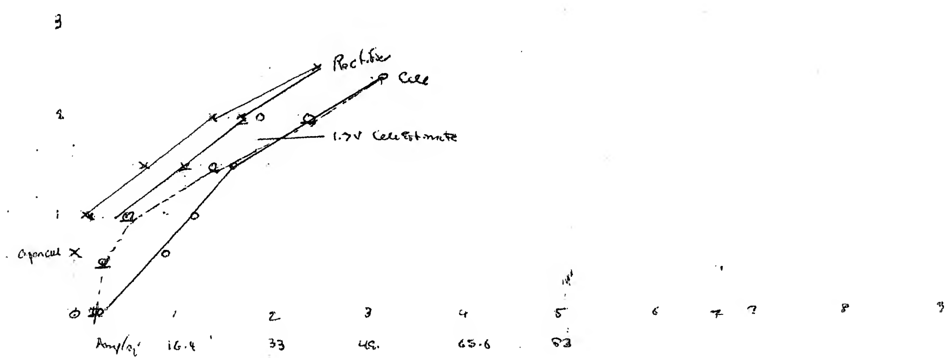
12/12 Carbon (Rubber) Generic (Not MW Rubber C Alm's)

121° S.S. Cathode Graphite Anode



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$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$ Melbo

Jan 12 2004

Sodium Chloride Cell. 1.0 ohms at 90°C 0.25 Volts with 55 Celsion

5g Al.

11°C Turned cell 0.25V small Current 53°

113 Celsion on 0.25V small current

V	Im Amp	Ref	V	A	A	
0.5	0.0	0.6V	0.9	0.1	0.1	-0
1.0	0.0	1.4	1.8	0.2	-0.1	-0.11
1.5	0.0	1.9	1.5	.05	-0.1	-0.3
2.0	0.15		1.8	.25	0.1	-0.5
3.0	1.0		2.3	~~1.6~~	+2.6	-2.0
2.0	0.7		2.0		0.6	-1.1
1.5	0.2	1.9	1.8		-0.1	-0.7
1.0	0.0	1.5	1.5		0.1	-0.1
0.5	0.0	1.7	1.0	0.15		
off 0.0	0.0	0.7	0.7	0.1		

100° 1.15 (beside row 1.0)

Switched to non Molfin electrode

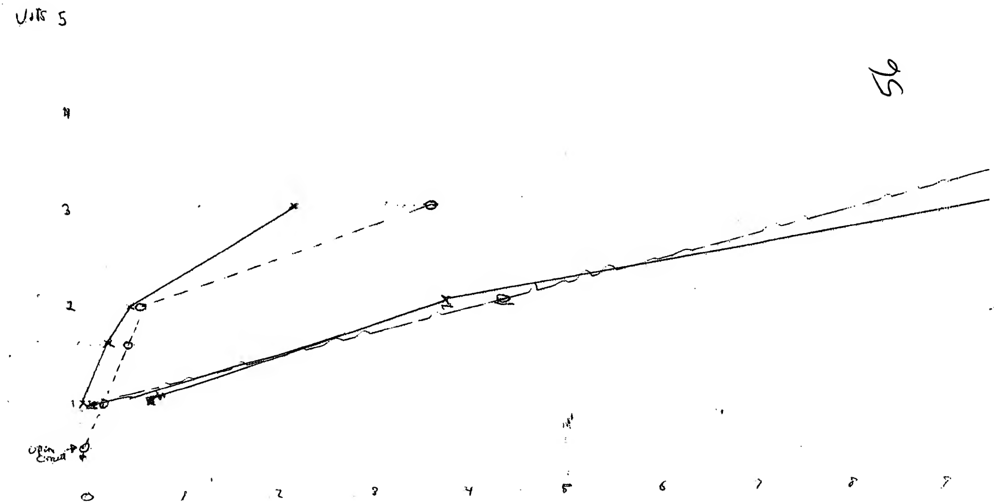
V	Im Amp	Ref	V	A	A	
off 0.0	0.0	0.9	0.3 little			
1142 0.5	0.0	0.8	0.8	.025		0
1.0	0.0	1.1	1.2	.05	0.1	-0.2
1.5	0.3	1.4	1.4	.05	0.45	0.45
2.0	0.4	1.4	1.6	.07	0.6	-0.4
3.0	2.2	1.9	1.5		3.5	-3.4
4.0	35.5	1.6	1.6		50.0	-50.0
3.0	10. 9.0				11.6	11.6
104°C 2.0	3.8	→	2.0		4.5	4.5
1.0	0	1.5	1.5	0.18	0.2	-0.1
1.0	0.1	2.0	2.0		0.3	-0.1

CRK

Cell NH4, Na_2CO_3, NaCl — Jan 14, 2004

	Temp			— Amperon			Amp	Amps
1100	130	0	0	0.6V / 5.3V	0.04 Amp / off		0.07	
1108	135	0.5	0.2 / 0.1	1.0	1.0		0.36 / 0.2	0.1 - 0
1110	133	1.0	0.2	1.2	1.2		0.4	0.2 - 0.3
1114	133	1.5	0.6	1.4 / 0.2	1.4	0.7		0.7 - 0.8
1115	133	2.0	1.4	1.5	1.8		1.8	1.6 - 1.9
1120	133	2.5	1.6	1.5	1.6			
		3.0	6.3					7.6 - 8.2
1125		2.5	4.2					5.4 5.8 / 5.0 5.4
		2.0	2.3	1.7	1.8			3.3 3.8
1142	138	1.5	1	1.5	1.6			1.8 - 1.8
		1.0	0.2	1.3	1.3			0.4 0.2
		0.5	0.0	1.0	1.0			0.2 0.0
				0.4 / 1.0	1.0	-.04 Amp		
		0 off	0.0	0.8 / 0.2	0.7 / 0.038			

NaCl Cell with C Same Solution 1/12/04 b.
Cell Carbon Anode SS Cathode Nearly touching a point
position



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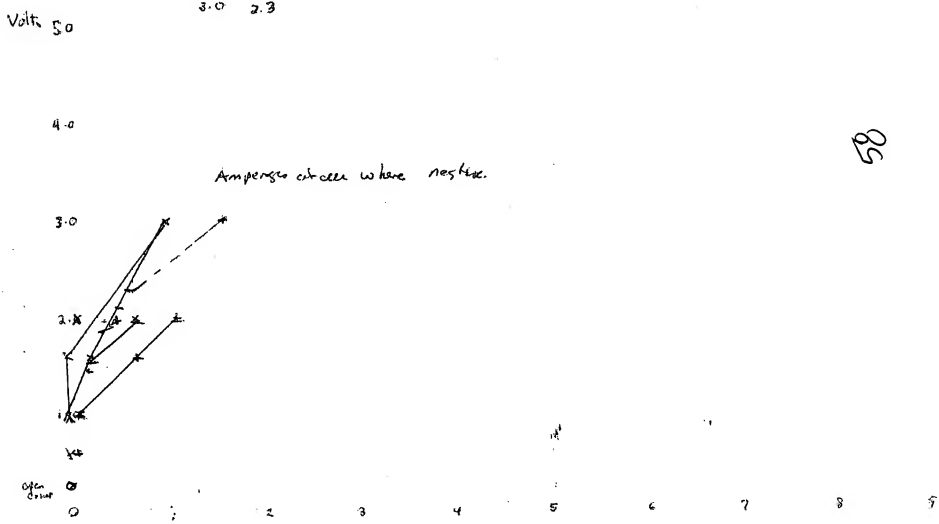
pex 2 Jan 12 2004

1201	2V	3.0A		-	2.2		3.8	-3.6
	2.5	5.2			25		6.2	-6.1
	3.0	8.3			28		10.2	-10.1
	2.0	2.8			22		3.5	3.4
	1.0	0.0			1.5	.075	0.15	-0.1
8	0	0	1.1		0.9		0	0

NaCl Cell with C 1/12/04 No Chlorine
@ 100°C Nafion Air disperser
1 Ohm at 90°C

Volts - 0.25V open circuit

Rectifier	Cell
0.5	0.7
1.0	1.2
1.5	1.5
2.0	1.8
3.0	2.3



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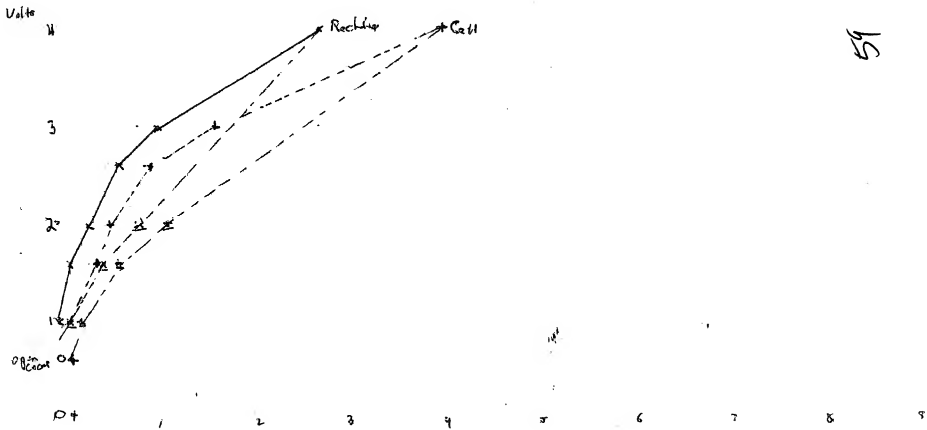
i. 13

Recycled NaOH Na_2CO_3 CeO_2 NaCl c ohms lo
125°C



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CFEC

Jan 13 2004
Karl Koren

Recycled VeOH, Na_2CO_3 56 gr NaCl 300 ~~Na_2CO_3~~ CO_2 Ohm=10

Nafion Temp 125 Volt 0.5 V 0.17 Amps

	Rectifier		Cell	Cell		Amp	
H_2O	V	A		V	A	+	−
	0	0	0.5	0.5	0.17	0.1	−0.1
	0.5	0	0.6	0.6		0.0	−0.1
	1.0	0	0.9	0.9	0.15	0.0	−0.2
	1.25	0.1	1.3	1.25	0.28	0.3	−0.2
	2.0	0.3	1.6	1.6		0.5	−0.4
	2.5	0.6	1.9	1.9		0.9	0.8
	3.0	1.0	—	2.3		1.6	1.5
	4.0	2.7		3.2		4.0	3.9 Foaming up to Elec
	2.0	0.8		2.0		1.1	1.1
	1.5	0.45	1.5	1.8		0.6	0.6
	1.0	0.1	1.2	1.4	0.2	0.3	0.4
Off	0.0	0.0	0.5		0.1		

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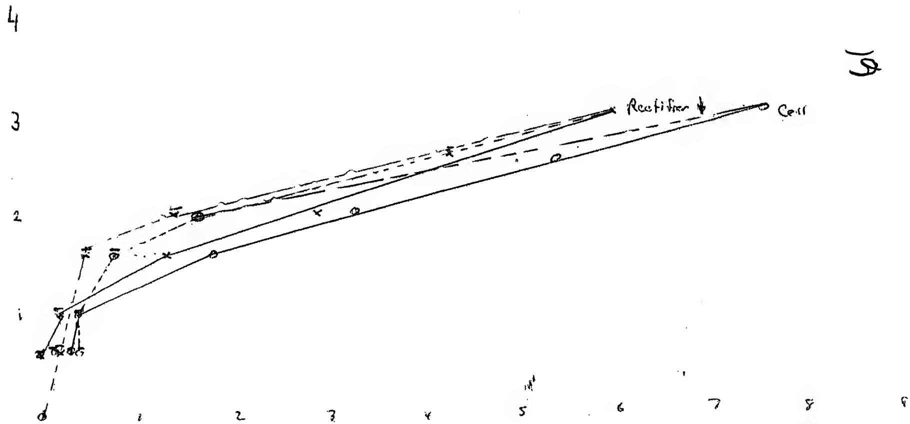
NaOH, Na_2CO_3 NaCl CeO_2 1/14/2007
No Nafion @ 135°C



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